This document references Chapters and Sections from the ITRC Vapor Intrusion Technical and Regulatory Guidance, and Fact Sheets and Technology Information Sheets from the ITRC Vapor Intrusion Toolkit, published January 2026. These resources can be accessed at: **https://itrcweb.org/vapor-intrusion-toolkit**.

SUB-SLAB DEPRESSURIZATION TECHNOLOGY INFORMATION SHEET

Active mitigation systems (uses electric fan)

This Interstate Technology and Regulatory Council technology information sheet provides basic information when using a fan to continuously depressurize the sub-slab environment to mitigate the potential for vapor intrusion (VI) at a given building. Sub-slab depressurization (SSD) is the most common engineering control installed in buildings at or near VI sites. The operational objective for SSD systems is to create a negative pressure below the building slab. Depressurization occurs when the pressure below the slab is less than that of indoor air.

Overview

An SSD system uses an electric fan to continuously create a negative pressure gradient across the subgrade portion of the building to mitigate the potential for VI from the subsurface into the building. Conversely, when a negative pressure is present within the building envelope relative to surrounding soil, advective gas flow from the soil into the indoor air can occur. Soil vapor entry pathways can be cracks through the slab or wall(s), improperly sealed utilities, etc. Depressurizing the soils below the slab with an SSD system will create a low pressure that reverses or alters the direction of soil vapor flow, thus mitigating VI. The types of fans/blowers used for SSD can vary depending on sub-slab material permeability, as well as the building type, construction quality, and size of the building being mitigated. SSD may be limited to the portion of the floor slab where vapor-forming chemical (VFC) concentrations exceed generic or building-specific screening action levels for VI.

General Design

SSD suction points can be constructed by coring through the slab or foundation, trenching in the slab, directional drilling from outside the building, or other methods of accessing the sub-slab soil. Typical system schematics are shown in **Figure 1** and **Figure 2**.

Most commonly, a vertical pipe of 3- to 6-inch nominal diameter is installed through a cored hole in the floor. A suction pit or cavity is created below the floor by removing approximately 1–3 cubic feet of soil or fill material to reduce resistance to flow and enhance vacuum propagation. The piping is sealed to the slab or foundation at the connection point with the cavity using durable caulking or air-tight pipe fittings. The permeability of the subgrade soils and the presence of cracks and openings in the building floor slab will affect the performance of the SSD. Best performance is obtained when the suction pit is left open (and not backfilled with stone or other material) and cracks/openings in the floor are sealed. Practitioners should understand vacuum, airflow, pressure differential(s), and the effects each has on the system design and operation. Detailed design specifications for design and construction of SSD systems are beyond the scope of this technology information sheet.

Existing in-depth standards for the mitigation of most building types have been developed and published by the American Association of Radon Scientists and Technologists (AARST), also known as the Indoor Environments Association (IEA), which is accredited as a standards development organization by the American National Standards Institute (ANSI). These ANSI/AARST Standards have been expanded to address both radon and soil vapor to incorporate considerations for VI. These documents can be viewed/accessed for free on the AARST Standards website (AARST 2025) and are generally updated every three years. These standards will continue to be labeled as ANSI/AARST due to historic name recognition for AARST, despite the rebranding of AARST to IEA.

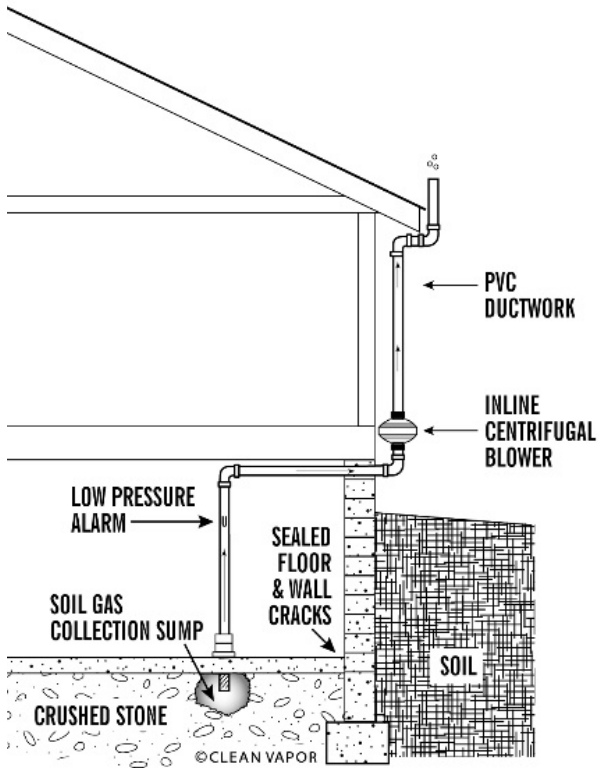

Figure 1. Example sub-slab depressurization system (fan outside).

Source: Clean Vapor, LLC, adapted from USEPA (1993), used with permission.

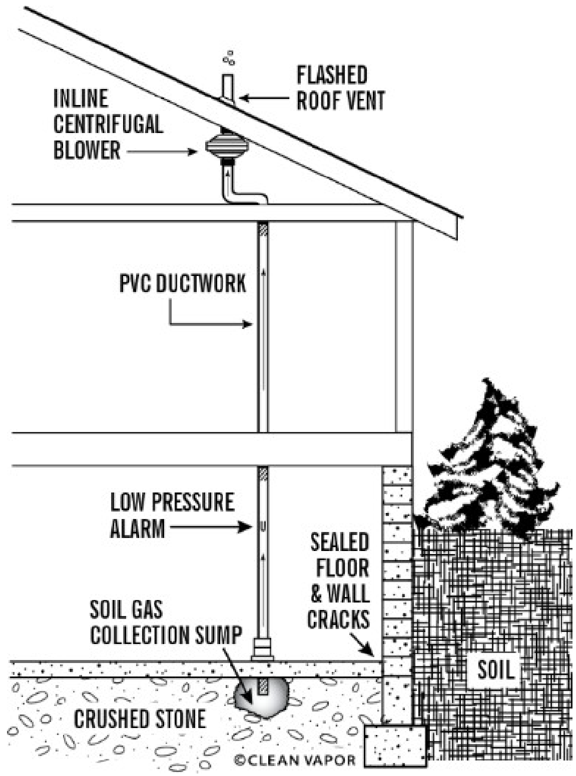

Figure 2. Example sub-slab depressurization system (fan in the attic, outside living building envelope).

Source: Clean Vapor, LLC, adapted from USEPA (1993), used with permission.

Information regarding design and operation can also be found in the Environmental Security Technology Certification Program (ESTCP) guidance documents (McAlary et al. 2018). Both ANSI/AARST and ESTCP resources provide technical information that can inform mitigation system design and operation.

New Building Design

SSD can be incorporated into the design and construction of a new building. The radon mitigation industry has a long history of using radon-resistant construction (USEPA 1994) based on guidance in the ANSI/AARST standards (AARST 2025, which provides specifics on the CCAH [Construction Code Applicable to Homes] for residential buildings and C-1000 for large buildings), and this guidance has been expanded to include mitigation of the VI pathway for VFCs. These techniques include installation of some or all of the following: a permeable subbase (or aerated slab with drainage mat or specialized forms), perforated collection piping, construction-grade geomembrane, solid riser piping extending above the roofline of the building to appropriate discharge locations, sub-slab probes or tubing run to exterior weatherproof box to monitor sub-slab concentrations and differential pressure across the slab, and accommodations (i.e., electrical connections) for fan installation.

Diagnostic/pressure field extension (PFE) testing can be completed after slab construction to confirm or adjust the fan/blower sizing.

If active mitigation is determined to be necessary for new construction, depending on the footprint of the new building, in-line fan(s) can then be installed on the exterior system piping or interior piping that is outside the heated/occupied building envelope, or large blowers can be installed outside the building or on the roof depending on space availability. Considerations should be given to the National Electrical Code for the mitigation of flammable gases. Vacuum influence is then measured at sub-slab monitoring points (located spatially throughout the mitigated area), and these data, combined with flow rates, mass removal rates, tracer tests, and/or multiple lines of evidence, may be used as necessary to demonstrate system effectiveness. A benefit of including a roughed-in active SSD system during new construction is lower cost compared to a retrofit, since a highly transmissive subfloor, in combination with SSD, requires less reliance on the performance of a resistive layer (i.e., a concrete floor and/or vapor membrane) and can be effective using fewer and smaller (lower electricity usage) fans.

Membranes Used with Sub-Slab Depressurization Active Mitigation

Although membranes are not typically installed with an SSD system for an existing building, installation of a membrane should be considered when SSD is implemented during new construction. The thickness and type of membrane selected and installed will depend on soil vapor VFC concentrations, design objectives, and construction logistics. Construction of a large building may consist of many penetrations in the membrane, which may create potential short circuiting if not sealed properly. As such, smoke testing of an installed membrane may be performed; however, this is typically more applicable to passive systems where a fully sealed barrier is more critical for effective mitigation.

Vapor membranes can reduce leakage across the floor, which enables the vacuum field to propagate farther and with less applied force than in cases where the concrete slab alone is the barrier. Therefore, the installation of a membrane can result in reduced energy consumption and long-term operating costs. The inclusion of a properly installed membrane may also provide some protection if the fan(s) are temporarily not operational.

For newly constructed buildings where lower VFC concentrations are expected to be present in sub-slab soil vapor, a relatively thin membrane consistent with radon mitigation practice may be considered for active systems. Reference the ANSI/AARST standards (AARST 2025). The standards for radon commonly call for a membrane (typically reinforced polyethylene or polyolefin) with a thickness of 10 mils. Caution should be applied in the selection of membranes with thicknesses 10 mils or less because they may be prone to damage during the construction process and make it difficult to achieve a reliable seal. Additionally, the interaction between the site constituents of concern and the membrane should be considered to confirm the barrier is designed to withstand contact with the contaminants of concern at the site. Installation of the vapor membrane should include sealing at seams, pipes, and other penetrations and sealing to the perimeter stem wall using sealants compatible with the selected membrane. See the ANSI/AARST standards (AARST 2025) for more information.

For newly constructed buildings where higher VFC concentrations are expected to be present in the sub-slab soil vapor, installation of a more robust membrane (i.e., minimum 20 mil thickness) should be considered for active systems. Soil vapor concentrations of VFCs may be considered high when concentrations are at least three orders of magnitude higher than an applicable sub-slab screening level. A more robust membrane would include products that are more resistant to diffusion of site-related VFCs (e.g., seamed, sheet-applied membranes that are installed with documented quality control procedures). More information can be found on those types of membranes in the **Passive Vapor Intrusion Mitigation Systems Fact Sheet** and associated supporting technology information sheets.

Components

Active SSD technology requires an electric fan/blower connected via piping to the space directly below the floor slab. The electric fan/blower can be installed on either the outside (see **Figure 1** and **Figure 3**) or inside (**Figure 4**) of a building, depending on available locations that are not within, adjacent to, or below occupied spaces. Typically, fans are installed on the outside of the building due to access issues both for system installation and for ongoing system operation, maintenance, and monitoring (OM&M). Fans installed on the outside of a building are subject to changing weather conditions and, depending on the geographic region, this may cause condensate issues and/or additional wear on the fan. Fans installed in interior spaces (for example, attics) must be fully excluded from occupied and/or insulated interior spaces (i.e., fans need to be located outside the occupiable building envelope) to mitigate the potential for leaks in the fan's vent from entering the occupied space.

Figure 3. Blower installation outside building.

Source: C. Regan, ERM, used with permission.

Installed large fans/blowers may need silencers to mitigate the noise from the fans. Fans installed in weather-protected spaces such as attics have a longer and more consistent operating life because they are protected from extreme weather conditions but also require permission from and coordination with the property owner to obtain access for each OM&M visit.

Figure 4. Blower installation inside attic, outside occupiable building envelope.

Source: Clean Vapor, LLC, used with permission.

The vent pipe from the fan/blower is exhausted above the roofline and away from building openings to avoid re-entrainment of exhausted vapors. See the ANSI/AARST standards (AARST 2025) for more information. Additional components may be warranted depending on site operational and regulatory considerations and may include vapor-liquid separators or moisture knockout tanks upstream of blowers to manage significant entrained liquids and air emissions treatment (i.e., activated carbon) either upstream or downstream of blowers. Generally, if treatment systems such as activated carbon are designed downstream of a blower, a heat exchange may also be required between the blower and carbon units, to lower the moisture content of the vapor stream and dissipate the vapor temperature prior to the vapors entering the carbon vessels, both of which typically will aid in treatment efficiency. It is important to identify early on in the design process whether vapor treatment will be needed, so that the blower and vapor treatment can be appropriately sized and space can be allocated for treatment vessels that is accessible for monitoring media performance and periodic replacement of media. If an air discharge permit is required, the permit typically needs to be obtained before construction begins.

Other features typical of an active SSD include the following:

- System piping, including a sampling port(s) for conducting system diagnostic testing (i.e., vacuum and air velocity/flow) and for collecting samples to measure VFC concentrations in the effluent in support of sub-slab vapor flux calculations, if desired.

- Permanent u-tube manometer (**Figure 5**), vacuum gauge, or pressure sensor on the system piping to monitor system pressures.

- Balancing valves on system piping can be used to improve PFE throughout the mitigation area, if needed. Balancing valves can also be used to reconfigure the system footprint as sub-slab vapor concentrations diminish over time. Blowers that have variable speeds may also be used to balance or rebalance a system over its operational life.

- In some cases, a condensate collection system in the form of a moisture holding tank (or similar) is included and, depending upon the site conditions and regulatory requirements, condensate treatment.

- Typically, the fan sizes required to mitigate VI into a residential or small commercial building will be much smaller than blowers used for VFC source remediation (e.g., soil vapor extraction systems); however, larger blowers are often used for mitigation in larger industrial buildings (including similar components to a soil vapor extraction system) to enable coverage of large building footprints and to accommodate vapor treatment.

Figure 5. Typical U- tube manometer.

Source: R Saari, Arcadis, used with permission.

- Although condensate formation is dependent on internal pipe temperature, SSDs need to be designed to drain condensate. This is done by sloping all horizontal piping at a minimum of 1 percent (consistent with mechanical code requirements). Horizontal SSD piping should be sloped to drain to the vertical extraction points to prevent piping from becoming clogged and inhibiting airflow. Additionally, horizontal PVC piping should be supported to the building at a minimum spacing of 4 feet to prevent pipe deflection.

Advantages

SSD as an active mitigation technology has the following advantages:

- SSD is an easily deployable engineering control that is often considered the most reliable and protective mitigation method.

- Performance can be reliably monitored by measuring the sub-slab pressure differential spatially throughout the area requiring mitigation.

- Continuous performance can be reliably monitored through telemetry connected to sub-slab monitoring point(s).

- SSD systems mitigate vapors from entering indoor air rather than relying on dilution or filtering of the vapors after they have entered indoor air.

- In-line fans, which can be used in most buildings with small footprints or higher permeability sub-slab soils, use a small amount of electricity and require no routine maintenance; therefore, OM&M costs are low.
- Systems are designed to minimize the disturbance/removal of indoor air; therefore, these SSD systems have a low impact on heating and cooling costs.
- Systems can also protect buildings from radon gas and reduce moisture levels in damp basements.
- SSD systems can be implemented on most building types, including existing and new construction, residential homes, and larger commercial and industrial buildings.
- Implementation of SSD during new building construction is a lower cost option, since a less robust construction-grade membrane can be used rather than incorporating a more robust barrier appropriate for passive mitigation.

Limitations

SSD as an active mitigation technology has the following limitations:

- Installation of SSD systems impacts the occupants of the building in that coordination with and cooperation of the building occupants is needed during system installation (for existing buildings) and ongoing OM&M (both new construction and existing buildings).
- SSD systems will not be continuously effective during high water table conditions where groundwater is in contact with the slab or within inches of the slab and occupies the pore spaces in the permeable subgrade materials. When this type of seasonal condition is anticipated during new construction, a passive VI barrier rather than a construction-grade membrane should be installed.
- Low permeability soils below the slab negatively affect the pressure radius of influence, requiring the installation of additional suction points and/or use of higher vacuum fans.
- Poor concrete slab construction, excessive cracks in the slab, or utility penetrations/floor drains/pipes may create short circuiting of airflow and potentially have a high energy penalty through loss of conditioned indoor air to the sub-slab. A substantial amount of sealing to limit indoor air from being drawn into the system and to enable overall system effectiveness may therefore be needed. Sealants may require OM&M as well.
- High permeability soils below the slab may not allow measurement of large negative pressure differentials away from a suction point(s), but this may not necessarily indicate the system is not operating effectively. High permeability soils will allow for increased sub-slab airflow compared to an SSD with low permeability sub-slab soils, meaning the system may operate more like a sub-slab ventilation system (SSV) as opposed to an SSD. The collection of alternative metrics to evaluate system performance (such as sub-slab airflow rate measurements, sub-slab concentrations, or tracer testing) may be considered to evaluate pneumatic influence at locations with negligible pressure differentials away from the suction point(s) in these conditions. For these reasons, care should be taken when evaluating SSDs with high permeability soils (whether native or engineered sub-slab material) because the absence of a measurable pressure differential away from the suction point may provide a false indication that the system is not working. The aforementioned considerations should be evaluated and reviewed carefully by those experienced in the design, operation, and monitoring of both SSV and SSD mitigation systems. Additional considerations for an SSV system are provided in the **Sub-Slab Ventilation Technology Information Sheet**.
- Installation of vapor exhaust controls may be necessary depending on the VFC concentrations in the subsurface, site type, and/or state air permitting regulations. Installation of these controls may

require the use of more robust blower systems, air permitting, and additional OM&M requirements for discharge monitoring and treatment media changeout.

- SSD systems may not meet performance requirements when required design and construction practices are not followed. Important differences in mitigation design, treatment of exhaust, and practitioner qualifications for VI and radon mitigation should be recognized and accounted for to achieve effective project implementation.
- For some properties, it may be difficult to prevent property owners, pets, or rodents from tampering with and possibly damaging system components.
- SSD systems may not necessarily prevent diffusion of VFCs across slabs and some vapor barriers if high concentrations are present immediately below the slab. SSD will not address some preferential pathway conditions such as conduit VI (i.e., vapors emanating from a closed conduit and discharging into a building). This condition is more likely to occur at existing buildings where solvent-impacted soils are present immediately below the slab and is less likely to occur in new construction where clean materials (e.g., gravel) are placed below the slab.
- Sub-slab utilities, pipes, or drains may result in short circuiting or developing preferential pathways that may affect the system radius of influence or bypass the SSD and continue to be pathways for vapor entry. Preferential pathways should be identified and sealed as part of a comprehensive SSD approach.

Cost Considerations

The primary factors that affect the overall cost of an active SSD system include whether an existing or new building is mitigated; building size; building height; building use; tightness of the soils; depth to water; building heating, ventilation, and air conditioning; condition of the slab; number of building additions; size and total number of blowers or fans; permitting; exhaust control (if required); condensate treatment (if required); remote monitoring; and OM&M.

In addition to construction costs, it is important to remember potential costs such as predesign testing; preparation of work plan(s), design, and specifications; installation monitoring; regulatory agency and stakeholder liaising; post-installation verification testing; and reporting. Additional cost factors may include but are not limited to the following:

- Sub-slab vacuum field extension
- Number of suction points
- Number of vacuum monitoring points
- Type and number of blowers
- Electrical requirements
- Building construction features
- Aesthetic considerations
- Noise considerations
- Exhaust filtration
- Condensate treatment and discharge
- Permitting, regulatory, and legal oversight

Special Circumstances

Special circumstances for construction of an SSD include the following:

- Insulation incorporating heat trace cable may be warranted to prevent freezing of condensate in cold climates or to dampen noise.
- High water tables or perched water where water is present directly beneath the building slab may require additional measures to achieve SSD system performance objectives or require sealing of floor sump and French drain systems to prevent VI while allowing water to be removed from the building as originally designed.
- If there is high airflow below the building, the technology implemented may be fully or partially an SSV system rather than SSD. Although SSV can be as effective as SSD, there are different factors to consider when determining the efficacy of venting versus depressurization. See also the **Sub-Slab Ventilation Technology Information Sheet**.
- Qualified personnel should conduct design, installation, and OM&M of control systems.
- Precautions should be taken to ensure that new tenants and/or construction activities (e.g., sub-slab utilities, service pits) do not damage the SSD system.

Occupant, Community, and Stakeholder Considerations

It is essential to develop and implement a site-specific community involvement plan that addresses how to win trust and gain access to properties, communicate risk to potentially exposed individuals, and minimize the disruption of people's lives and businesses. For more details see **Chapter 3: Community Engagement**.

REFERENCES

AARST. 2025. "ANSI/AARST National Consensus Standards." **https://standards.aarst.org/**.

McAlary, T. A., W. Wertz, and D. Mali. 2018. *Demonstration/Validation of More Cost-Effective Methods for Mitigating Radon and VOC Subsurface Vapor Intrusion to Indoor Air*. U.S. Department of Defense: ESTCP. **https://clu-in.org/download/issues/vi/ER-201322-Final-Report.pdf**.

USEPA. 1993. *Radon Reduction Techniques for Existing Detached Houses, Technical Guidance (Third Edition) for Active Soil Depressurization Systems*. United States Environmental Protection Agency. **https://www.wbdg.org/FFC/EPA/EPACRIT/epa625_r_93_011.pdf**.

USEPA. 1994. "Model Standards and Techniques for Control of Radon in New Residential Buildings." *Air and Radiation*. **https://archive.epa.gov/epa/sites/production/files/2014-11/documents/model_standards.pdf**.